Speed Management in Work Zones – The ASAP Project

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Abstract

Speed management of traffic in work zones is important for the safety of both the road user and road worker. A work zone will introduce deviations from normal travel in a discrete road section and appropriate speed is needed to ensure that the driver can navigate the vehicle through the work zone, particularly if there are abrupt lateral deviations from general road design norms. The Conference of European Directors of Roads (CEDR) is funding transnational road research projects regarding work zone safety in the 2012 Safety Programme. The ASAP project - Appropriate Speed saves All People - addresses the issues of speed management in work zones. The European state of the art for assigning work zone speed limits is presented with initial data collected in different work zones. Global experiences with enforcement strategies for works zones are also presented.

Keywords: Work zone, speed, safety, guidelines, enforcement.

Résumé

La gestion de la vitesse du trafic au droit des zones de travaux routiers est essentielle pour la sécurité de l'usager et des travailleurs. Un chantier routier introduit des écarts par rapport aux conditions normales de circulation sur une section de route donnée, et une vitesse appropriée est nécessaire pour assurer que le conducteur d'un véhicule puisse traverser la zone de travaux sans encombre, en particulier s'il y a des déviations brusques par rapport aux normes habituelles de conception. La Conférence Européenne des Directeurs des Routes (CEDR) finance des projets de recherche transnationaux sur le thème de la sécurité des zones de travaux, dans le cadre de son programme Sécurité lancé en 2012. Le projet ASAP - Appropriate Speed saves All People - (littéralement: une vitesse appropriée sauve tout le monde) aborde les questions de gestion de la vitesse dans les zones de travaux routiers. L'état de l'art européen en matière de sélection des limites de vitesse au droit des chantiers routiers est présenté avec quelques premières données collectées dans différentes zones de travaux. Des expériences mettant en œuvre des stratégies de répression dédiées aux zones de travaux sont également présentées.

Mots-clé: zone de travaux, vitesse, sécurité, lignes directrices, répression

1. **Introduction**

Speed management of traffic in work zones is important for the safety of both the road user and road worker. The driver will be distracted by the introduction of new road markings and signs, construction equipment, road workers moving in close proximity to traffic, and physical changes to road surfaces and layouts. The work zone introduces deviations from normal travel in a discrete road section and appropriate speed is needed to ensure that the driver can navigate the vehicle through the work zone, particularly if there are abrupt lateral deviations from general road alignment. The combination of traffic, work equipment, and road workers in a small area introduces the risk for collisions leading to injuries for both the road user and road worker.

Safety procedures for works zones are used by most countries but the type and level of application varies depending on the country and jurisdiction. From a European point of view, it is important that road users understand and can follow the work zone requirements even if they are not in their home land. The Conference of European Directors of Roads (CEDR) is funding transnational road research projects regarding work zone safety in the 2012 Safety Programme. Four specific research themes were identified for this call and the ASAP project - Appropriate Speed saves All People - was designed to address the issues of speed management in work zones *(Programme Area C)*. The main objectives of ASAP are to develop harmonized best practice guidelines and financial implications of work zone speed control for Europe. A common reference should be made available if European road users and road workers are to have a high level of safety, regardless of the country or region.

A National Cooperative Highway Research Project (NCHRP) study conducted by Migletz et. al., (1998) reported that the safest traffic flow occurs when all vehicles are traveling at approximately the same speed, which means that the range of speeds is within a relatively narrow band. As speed variance increases, motorist crashes tend to increase. Furthermore the results showed that the safest work zones are those with the smallest increase in the upstream-to-work-zone speed variance and that speed compliance in the work zones is generally higher where the speed limit reduction is lower than 16 km/h (Migletz et. al. 1998). They also state that in work zones without a speed limit reduction, the percentage of vehicles exceeding the speed limit was in general lower inside the work area than upstream by 21.7% .

Migletz et. al. (1998) also noticed that the percentage increase in speed variance within the work zone, compared to conditions upstream from the work site, appears to have a minimum for a speed limit reduction of 16 km/h. For work zones without a speed limit reduction, the speed variance in the work zone was 61% higher than the upstream speed variance (Fig. 1).

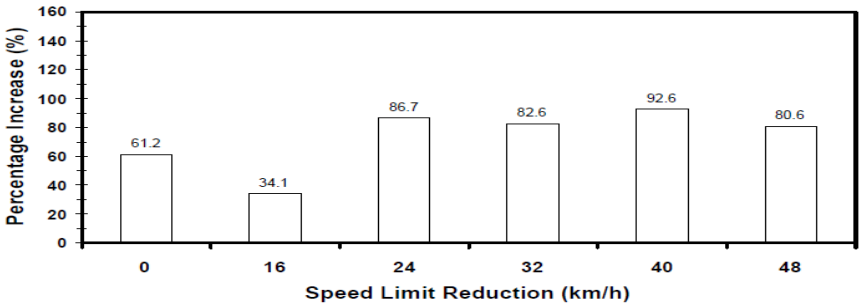

Fig. 1: Increase of speed variance in work zone from upstream conditions as a function of speed limit reduction, from Migletz et. al. (1998).

The relationship between injury rate and work zone speed limit reduction was also studied by Migletz et. al. (1998). The increased risk of injury in a work zone, compared to standard conditions, is presented in Figure 2. Work zones where the injury rates have the minimum change (increase) from reference levels have a speed limit reduction of 16 km/h (on rural freeways). Work zones without speed limit reductions had the next smallest percentage increase in the fatal-plus-injury accident rate, but not the minimum. Both Figure 1 and 2 indicate that speed variance and injury accident rate are correlated, at least for the US roads investigated by Migletz et al. in Report NCHRP 3-41 (1998).

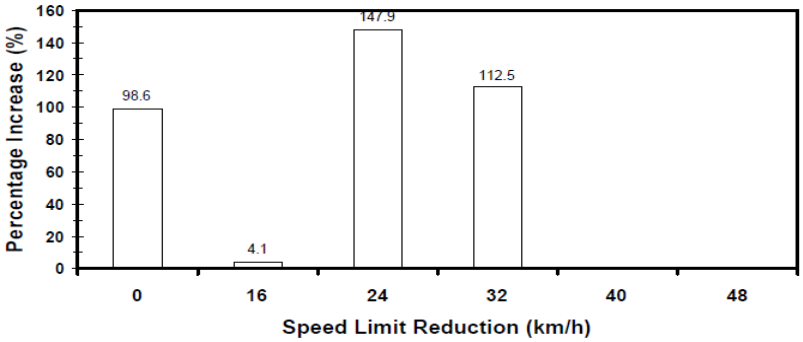

Fig. 2. Increase of fatal injuries in work zones compared to normal traffic as a function of speed limit reduction, from Migletz et. al.(1998).

The results presented above show that the speed of traffic through a work zone affects the safety of road users and road workers in the work zone. What is not clear is what speed limit or speed variance provides the best safety for different work zones types and if these results are valid for different regions, vehicle fleets, etc. Knowing which speed management method is best suited for delivering the desired speed distributions is also important information to provide in a work zone guideline.

A poll of members of the AASHTO Highway Subcommittee in the 1990's stated that safety problems in work zones are aggravated by the lack of uniform guidelines for determining speed limits (Migletz et. al., 1993). The inconsistencies in the methods used to determine work zone speed limits, the non-compliance with the posted speed limit by motorist, and the growing practice of setting work zone speed limits through administrative decisions without the support of an engineering study were identified as the major contributors to this safety problem.

One of the difficult issues facing work zone safety guidelines is to find comprehensive data which can be used to develop policies and specifications. The US has developed the Workzone Safety Clearinghouse (TTI, 2013) as one method to address this issue for their domestic needs. This initiative is financed by the Federal Highways Administration (FHWA) and is maintained by the Texas Transport Institute. Some references to European projects and local information are available but no similar resource exists for Europe. It is difficult to compile an overview of road safety issues for the EU28 without harmonized data. The European Union has some initiatives to collect road safety data but the details of the data collection do not extend to work zone information. Information on work zone speed measurements is even more difficult to obtain.

General information on work zone safety indicates that the US had 831 fatalities in work zones in 2007 which was 2% of the 41 259 fatalities. This is similar to the case in the Netherlands for the years 2000-2009 (SWOV, 2010). A report for the years 2003-2007 in Sweden (Liljegren, 2008) reported that work zone injury accidents were 0.6% of the annual injury accidents and associated fatalities were 0.9%. The report from Sweden also identified the problem of identifying accidents in the police databases as 27% of the work zone accidents were not explicitly coded as such in police reports.

The previous discussion identifies the problems in first identifying data sources that can be used to analyze work zone safety, in particular the effect of speed in work zones. Some international resources are available but information is still limited. There are also different safety levels achieved in different countries. Sweden has half the work zone fatalities as the US and the Netherlands based on proportion of annual fatalities, but is this due to differences in work zone practices, road network composition, or differences in population sizes? These questions cannot be addressed easily with the available studies and data.

In addition to the problems in compiling work zone related accidents, the speed data related to work zones are also difficult to obtain. There is a need to collect an overview of the speed management guidelines and identify what speed and safety data can be collected for the same work zone locations. This can be used as a base for future research and best practice development.

The main objective of the ASAP project is to gather knowledge on effective speed management measures for road works zones through literature review, information gathering from national expertise and practitioners, on-going research in Europe and abroad, and stakeholder consultations. The accumulated information will be documented to provide practical and readily understandable recommendations as to how to effectively manage speed through road works zones, in terms of

- engineering, design, and conspicuity of road works,
- enforcement and
- driver education/information,

with the aim of reducing risks to road workers without significantly increasing risks to road users.

2. **Method**

Five different partners from five different EU member states are participating in the project funded by the Conference of European Directors of Roads (CEDR). The project is funded under the 2012 Transnational Road Research Programme: Safety. The ASAP project has four technical work packages and the project plan can be seen in Fig. 1. The project started with an initial activity to identify the state of the art by looking at available practices (typically published guidelines) and previous research. Available data on work zone speeds will be collected and analyzed. Using a synthesis of current practices and the available evidence on speed management strategies, a demonstration and communication platform in the project will begin in the second half of the project. A list of the different countermeasures for speed management will be reviewed to identify a strategy to consult the relevant stakeholders. The stakeholder interests will be used to define small field studies focussing on low cost measures. These field showcases will be developed to provide practical reference data as well as demonstrating the implementation issues for a road owner or operator. The project will be finalised with documentation of the project results in a harmonised guideline for speed management that should be effective for the European community. The project started in February 2013 and will be finalized in January 2015. The project reports to a CEDR Programme Executive Board (PEB) representing the countries sponsoring the project.

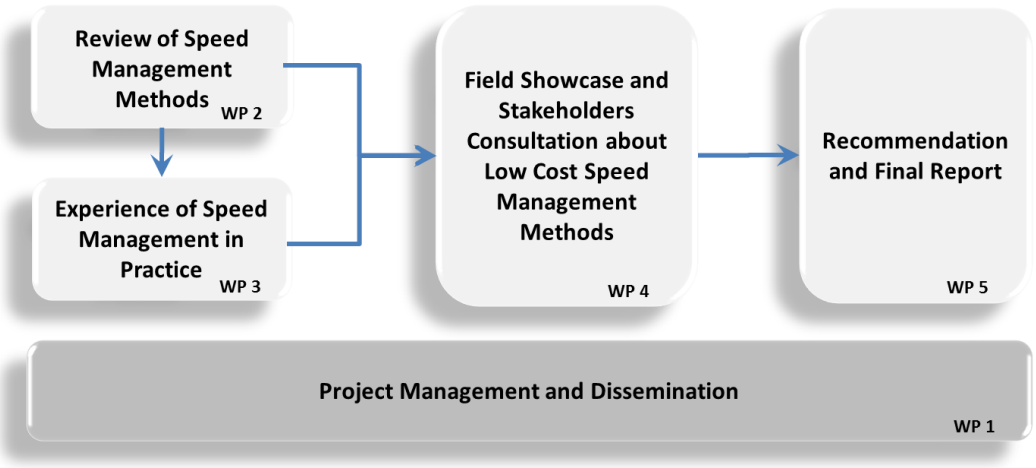

Fig. 3. Project Structure in ASAP project.

3. **Results to Date**

The project is due to be completed in 2015. The first work package is complete and the second is half complete at the time of writing. Some initial results are presented at this time covering the review of existing guidelines and initial results from the data gathered from available field measurements.

3.1. Review of Speed Management Guidelines and Technical Reports

The ASAP partners collected a large number of documents covering work zone guidelines, effectiveness of speed managements methods, and effectiveness of graduated penalties. The guidelines for a number of countries were collected and an overview of the European countries is given in Fig.4. The guidelines from the green shaded countries have been reviewed and compiled while the guidelines for the yellow countries (Finland and Iceland) have only been collected but not processed. In addition to the European guidelines, information from the US, Australia, and Canada was also obtained. Some regional guidelines were identified within some countries. The most notable case is that for the US where several states guidelines were found as well as a national reference document provided by the Federal Highways Administration (FHWA, 2009). The consortium members reviewed more than 250 separate documents which were then compiled into a common project report (Nocentini et. al, 2013).

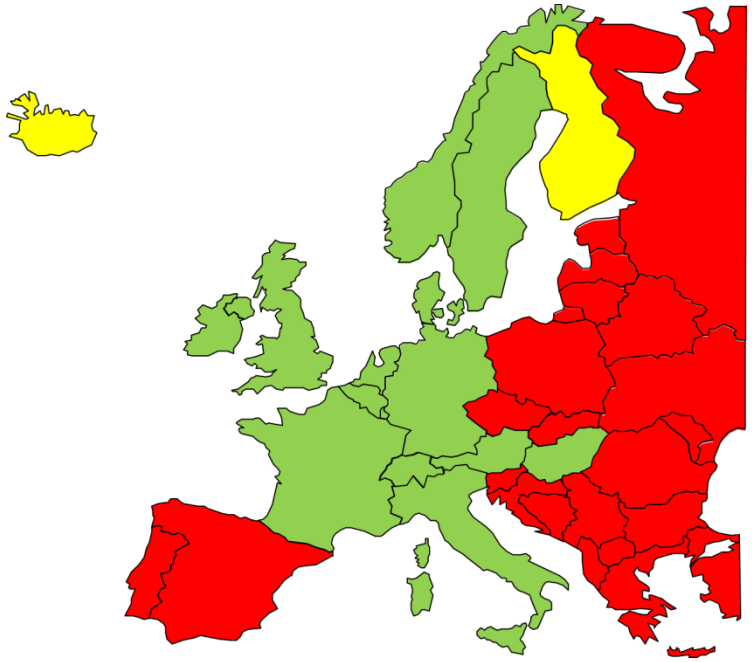

Fig. 4: National Work Zone Guidelines Collected in Europe

Selecting a work zone speed limit has several elements that need to be considered. To avoid linking work specific activities (i.e. paving, painting, excavating, etc.) to the speed requirements, variables that could be linked directly to the traffic management system were investigated. The main factors identified were:

- Original posted speed limit
- Type of road
- Reduction of lane widths in the work zone
- Reduction in number of lanes
- Presence of workers
- Changes in road surface properties
- Presence of crossovers
- Duration of road works

There is a common theme in many national guidelines that speed reductions in work zones should be avoided if possible. As identified by Migletz, et. al. (1998), there can be little gain in safety for large speed limit reductions, depending on the wok zone design. Ideally, work zones should be arranged to intrude as little as possible on normal traffic. When lowered speed limits are required there were some criteria commonly used in many countries but the specific details differs among the countries and regions. However there are still construction conditions that require work zone designs that require significant speed reductions from normal traffic operation.

A general summary of the eight different criteria used to define work zone speed limits is provided in Table 1 for the guidelines reviewed. An "X" indicates explicit use of the factor in setting speed limits. In general all countries are using original posted speed limit and/or road type as an important factor for work zone designs. Similarly, the presence of workers, their proximity to traffic, and the duration or physical length of the work zone are also relevant for assigning work zone speeds.

Many documents mentioned that speed limit changes should be avoided when there is no activity in the work zone or if the work zone is long, because the driver tends to get impatient. Several references were made to driver irritation or impatience for longer work zones.

Reductions in lane widths and associated speed reductions were not described in all documents but tables linking maximum posted speeds for associated lane widths were reported by some countries. Table 2 is an example from Austria.

Table 1. Summary of Parameters Used to Assign Speed Limits in Work Zones

	Original Posted Speed	Road Type	Lane Width	Duration or Length of Construction	Workers Present	Proximity of Workers to Traffic	Impact on Traffic	Changeovers and Crossovers	Change in Road Surface Properties
Australia									
New South Wales		X		X					X
Queensland		x			X	X			X
Austria		X	X		X		X	X	
Belgium	X	X	X				X	X	
Canada									
Quebec	X	X	X						
Czech Republic		X							
Denmark	X	X		X	X	X			
France	X	X			X		X	X	
Germany		X	X						X
Ireland	X	X		X	X	X			
Italy	X	X						X	
Luxembourg	X	X	X				X		
Netherlands	X	X		X	X	X			
Norway	X	X		X	X	X	X	X	X
Sweden	X		X	X	X	X			
Switzerland			X		X	X			
United Kingdom	X	X		X	X	X			
United States									
MUTCD				X	X	X			X
Michigan	X			X	X	X			
Minnesota	X	X							
New York				X	X				
Washington		X	X			X			

Table 2: Minimum widths of lanes in function of speed limit (ASFINAG, 2007).

Vehicle	Speed limits		
	60km/h	80km/h	100km/h
Trucks+Cars	3.00m**	3.25m*	3.50m
Truck	2.50m**	2.50m**	3.00m
* Or the width of two lanes one direction at least 6.00 m; ** Absolute minimum widths, for longer durations at sites with a length of more than 6.0 km are recommended minimum lane width of 3.25 m (truck and car) and 2.75 m (cars);			

Although there are some common parameters used by different countries to assign work zone speed limits, there is a great deal of variation in how the factors are used to define speed limits. While some countries have documents describing small speed reductions (in line with the Migletz (1998) results), there are still other countries describing multiple levels of 20 km/h speed reductions or 30 km/h steps. Another issue with the existing guidelines is that many speed limits are not automatically assigned but are based on the judgment of the analyst. Many documents refer to subjective interpretation of the work zone conditions and there is no easily identified nomograph, flowchart, or similar procedure that can objectively determine appropriate speed limits. Further analysis with actual speed and safety data is needed to determine if any uniform work zone speed limits can be derived in a generic guideline for Europe.

3.2. Collection of Speed and Safety Data.

The state of the art review of work zone speed limits also included the collection of field studies, ongoing projects and related data on work zone speed limits. As mentioned above, there is difficulty in finding comprehensive work zone speed data that can be correlated with the corresponding safety data for the work zone in question. ASAP collected available work zone speed and safety data elements addressing the work zone layout (number of lanes, speed limits, etc.), the enforcement types used, information signs used, etc. and their correlation to accidents. The data elements from the different sources were compiled into the database format presented in Appendix A.

Raw speed data may not be available for all studies and the use of speed management information available in previous research reports is also being collected. For example, a TRL study of different work zone speed management methods at night showed different speed limit compliance depending on the information sign used (Wood et. al. 2010). As the actual speed data is not available, the statistics and conclusions from the report cannot be included into the detailed dataset.

A total of 43 sheets were submitted covering 25 different work zones. There are more data sheets than work zones as there are different traffic conditions within the work zone for each direction of travel or a modification of the work zone layout during the construction period. The collection included data from 6 different countries (Austria, Belgium, Czech Republic, Sweden, Switzerland, and USA).

A first analysis of the completed sheets showed that there is a striking lack of information in this area. The data was not harmonized in all cases but there were several variables that were shared by several studies allowing some future analyses to be conducted. Information like average speed and 85%ile speeds were listed for some studies but only a few have crash injury reports that allowed direct calculations of safety to be conducted. Most of the speed data was reported for the periphery of the work zone, studying the speed reduction during the approach to the work zone. Many of the cases are for motorways and similar high speed facilities (posted speed >100 km/h).

To perform a statistical analysis the first step was to make a categorization so that the various parameters could be better compared. Sheets with deficient data source were removed from the analysis. A statistical analysis was attempted with 36 samples where speed data was reported for specific work zone layouts. During this analysis it

was determined that the number of existing data sets is insufficient for statistical analysis and many details are still missing in the existing data sets. There was not enough data found - especially for the crucial points related to “speeds” and “accidents”. Only 7 data sets provided information on traffic accidents or traffic victims. For the other data sets it was not possible to confirm if a lack of reported data was because no incidents or accidents occurred or if the data was simply not recorded.

In an attempt to extract some information, 24 datasets were used to compare measured speed with posted speed using the V50 and V85 statistics. In only 9 cases were average speeds below the posted speed. Further analysis is underway but anecdotal information suggests that speed management methods are strongly influenced by the road use (commuter, long distance, cross border, etc.) and indicates the challenge for European level guidelines.

There are several parameters under investigation and this requires a sufficient sample size and data quality to separate the effects of the parameters and to understand their combined effects. To perform any further analysis, additional measurements and investigations would be required which is unfortunately out of the project scope.

The ongoing analysis in ASAP will report any correlations that can be made for assigned speed limits and speed compliance measured in traffic. The types of speed management tools used will also be reported. A descriptive analysis and collection of experiences as well as the detection of generally accepted safety measures will be documented. For example, one case study identified a work zone that had two different speed limits during its construction period. There were more crashes observed when the work zone speed was lower with a narrower lane width than the case with a higher speed limit but wider lanes. Because of the interaction of the different parameters, it is important to collect performance data for a number of work zone designs.

On going work is reviewing the speed management methods and their impact on safety based only on the crash data and work zone design information. These before/after studies will report the relative safety of the work zone to normal traffic conditions, but without speed measurements, for the work zone.

4. **Discussion and Conclusions**

The initial data collection of different guidelines and work zone speed measurements has been collected within the ASAP project. The goal of the project is to develop generic guidelines that will allow road authorities and road operators to assign appropriate work zone speed limits. Although detailed work zone layouts and assessments are not part of the project, different field showcases (or demonstrations) will be conducted in the project to identify the effectiveness of different low cost speed management tools.

The survey of national guidelines shows that there are some common variables or factors that are used to assign work zone speed limits. Unfortunately the details associated with these common variables vary greatly between the countries and impose a challenge to identifying a generic European approach. However, the information in Table 1 provides the main criteria that would be needed for guidelines. The next step is to identify the core parameters and how they should be combined.

Speed measurements from work zones have been collected and analyzed in the project. Initial reviews of the data indicate that any detailed statistical conclusions will be difficult due to the lack of harmonized data collection and reporting. General observations using hypotheses like Nilsson’s Power Model (Nilsson, 2004) may be useful for recommending general speed limits although the model is not validated for work zone applications where normal driving is disturbed by atypical driving conditions (i.e. proximity of equipment and workers to the travel lane, lateral deviation of traffic, etc.).

Final results from the ASAP project will be available in 2015.

Acknowledgements

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Appendix A.: Data Fields Collected in ASAP

Country:	Date (DD.MM.YYYY): Start of Work		Street name/number:	From highway kilometre	
	Date (DD.MM.YYYY): End of Work			to highway kilometre	

Work Zone Layout

Type of Road				
Duration in days	0			
Length in km				
WZ in both directions				
	1.Direction			
Original Number of lanes				
Lanes in WZ				
	1. Lane	2. Lane	3. Lane	4. Lane
Original lane width in m				
Lane width in WZ in m				
Diversion on opposite lane				
Lane management (4+0,3+1,2+2,etc.)				
Lay-bys, Shoulders, Emergency lane		Distance between Lay-bys in m		
Number of entrances in WZ		Number of exits in WZ		
Safety measures and treatments				
Measures for Workers Safety				

Information Devices

Speed Limits				
	Regular	Periphery of WZ (upstream)	WZ	Periphery of WZ (downstream)
Speed Limits				
Distance to WZ				
Variable message signs				
Pre-information				
Actual speed information				

Enforcement Devices

Radar enforcement			
Section control			
Police enforcement			
	Minimum penalty	Maximum penalty	
Range of penalties			
Fixed graduated penalties			

Traffic Data

Overall			
Cross-section speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
average speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
1. Lane			
Cross-section speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
average speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
2.Lane			
Cross-section speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
average speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
3.Lane			
Cross-section speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			
average speed	Regular	Periphery of WZ	In WZ
V85-speed			
V50-Speed			

	Average daily traffic	max/h	max/day
Traffic Volume (per direction)			
Capacity in WZ (per direction)			
Headway in sec			
Vehicle class in %	Car		
	Truck		
	PTW		
	Type	Number	Location
Total Accidents during WZ-duration			
	Fatal	Severe injured	Slight injured
Traffic victims			